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ABSTRACT

Four new Project SOLO modules are presented here: Langragian Interpolation/Extrapolition, Optics, Chemistry (Laboratory Style), Chemistry (Boy/Girl Style). The latter program is a computer dating system which proved to be very popular with the high school students who developed it. (JY)

PROJECT SOLO

AN EXPERIMENT IN REGIONAL COMPUTING FOR SECONDARY SCHOOL SYSTEMS

University of Pittsburgh • Department of Computer Science • Pittsburgh, Pennsylvania 15213

Newsletter No. 21 January 25, 1972

To Each His Own

Any doubts about the reality of "individual differences" in learning style vanish into thin air when teacher/student control of computing is given free play. Any doubt about the continued importance of adult guidance and professionally prepared learning materials for such a "free" atmosphere also goes up in smoke in face of the requirements of such a computer supported learning system. The supposed conflict between structure and freedom turns out to be non-existent. Freedom builds on structure, and structure makes freedom possible.

The four modules enclosed with this newsletter illustrate a range of approaches to computer-related instruction and learning which reflect some of the differences in style that are possible within an educational philosophy that integrates researcher-teacher-student ideas.

Lagrangian Interpolation/Extrapolation

This module was prepared by Frank Wimberly of the Project Solo staff. It illustrates the kind of contribution to computer learning that can best be made by authors with professional mathematical computing backgrounds. A follow up unit which applies the material in this module to plotter displays (such as the HP-7200) is also being prepared by Frank.

Optics

This CAI unit is the combined effort of Allderdice physics teacher John M. Shore and student-teacher Bernie Meisner. The ability of students to use the computer to calculate answers within the CAI dialogue provides valuable problem solving experience for students.

Chemistry (Laboratory Style)

The idea for the /SPEX/ programs enclosed originated with Mrs. Dolores Kubiak, chemistry teacher at Allderdice High. The programs were developed by student Joel Berez and are in use by fellow chemistry students. Mrs. Kubiak encourages students to use the output of these programs as part of their lab reports. As can be imagined, these students think automation is O.K.

Chemistry (Boy/Girl Style)

The computer dating system described on the following pages was designed and implemented by student Leon Sweer (12^{th} grade). Unfortunately we have had to discourage use of the program. The lines of students who wanted to participate taxed the school's terminal capacity to the bursting point. There must be a lesson somewhere in this.

COMPUTER DATING

Certainly not a new idea in computing, but one that lends itself to many variations, is that of a computer dating service. Even though such services are generally not associated with time sharing systems, the ability to store large data files on the Com-Share system makes one possible. The following is a description of such a service which I designed using the NEWBASIC language.

How the Service Operates

The basic requirements of such a service are:

1. That a pool of information be set up for each person as a basis for comparing the "compatibility" of two people and that this information be stored on files for later use.
2. That the information of one individual can be retrieved and compared against the information of the other people on file (of the opposite sex, of course) in an attempt to come up with someone "compatible".
3. That some type of rating system be set up to determine the so-called "limits of compatibility".

In my service, these requirements are fulfilled by using two data files (one stores the boys' information and one the girls') and two NEWBASIC programs. The first program, named /DATE/, asks the user to supply certain pieces of information about himself or herself. The first ten items are merely to record name, address, and other such information. The rest of the program asks questions about personality, interests, and what type of a date he (or she) would prefer. This information is stored on the appropriate data file (/BOYS/ or /GIRLS/). These questions are not necessarily the best possible ones that could be asked, but they are enough to gain some insight into what type of person the user is and what type he (or she) would like.

The actual comparisons, however, take place when another program, named /COMPILER/, is run. For simplicity, the service is set up so that the user does not have access to this program. Rather, the person supervising the service runs all of the names through at one time during the week. This also helps minimize costs.

When the name and sex of someone on file is entered, the information under his name in the appropriate file is read into core as well as the entire contents of the opposite sex file. Comparisons are made one item at a time on a point basis. For example, if the person whose name was typed has indicated that he would like someone about the same age, and the age of the person from the other file is close to his, 20 points are added to the score of that person. Thus, at the end of all the comparisons, there will be as many scores (stored in array S) as there were people who were compared with the entered name. The highest possible score is 135 points. Anything above 110 is considered a very good match, and anything above 80 is considered to be a fairly good match. The computer then reviews the scores and prints the names of the people whose scores fell within those high ranges. All data, of course, is then read back into the data files to be used again. The listings which follow contain notes on programs and their functions. Following the listings are sample runs of both /DATE/ and /COMPILER/.

PROJECT SOLO / Dept. of Computer Science / Univ. of Pittsburgh (15213)
Module #0130 / Leon Sweer (S)

/COMPILER/

```
80 DIM S$(30,30)
90 DIM I$(25,25)
95 DIM S(25)
100 PR. "                    DATING COMPILER,     VERS. DEC. 1, 1971"
145 PR. PR. PR. PR. "LAST NAME-              ": ACCEPT N$
147 PR. "FIRST NAME-             ": ACCEPT F$
149 PR. "SEX-": ACCEPT S$
```

145-149

INPUT NAME & SEX

```
150 IF ICO(S$,"F",0) OR ICO(S$,"G",0) THEN 155
153 OPEN '159WR /BOYS/' FOR INPUT, 3
154 GOTO 156
155 OPEN '159WR /GIRLS/' FOR INPUT, 3
156 INPUT FROM 3, A
160 FOR I=1 TO A
162 INPUT FROM 3, S$(I,H) FOR H=1 TO 25
163 IF LEFT(N$,3)=LEFT(S$(I,1),3) THEN 164 ELSE 165
164 IF LEFT(F$,2)=LEFT(S$(I,2),2) THEN 167
165 NEXT I
166 PR. "NAME NOT FOUND (RUN 159WR /DATE/)" CLOSE 3 END
167 LET I$(1,Q1)=S$(I,Q1) FOR Q1=1 TO 25
170 CLOSE 3
```

150-200

CHECK TO SEE IF NAME ON FILE

```
200 IF ICO(I$(1,7),"F",0) THEN 250
210 OPEN '159WR /GIRLS/' FOR  INPUT, 3
220 INPUT FROM 3,A
225 FOR I=2 TO A+1
227 INPUT FROM 3, I$(I,C) FOR C=1 TO 25
228 NEXT I
229 GOTO 300
250 OPEN '159WR /BOYS/' FOR  INPUT, 3
255 K=1
260 GOTO 220
```

200-300

READ ENTIRE CONTENTS OF OTHER FILE

```
300 CLOSE 3
301 FOR C=2 TO A+1
302 IF LEFT(I$(1,12),3)="OLD" AND LEFT(I$(C,12),3)="YOU" THEN 310
303 IF LEFT(I$(1,12),3)="YOU" AND LEFT(I$(C,12),3)="OLD" THEN 310
304 IF LEFT(I$(1,12),3)="SAM" AND LEFT(I$(C,12),3)="SAM" THEN 310
305 GOTO 400
310 IF ICO(I$(1,12),"OLD",0) LET G=1
320 IF ICO(I$(1,12),"YOUN",0) LET G=2
330 V=VAL(I$(1,17))-VAL(I$(C,17))
340 IF G=0 AND -.5<=V AND V<=.5 LET S(C)=S(C)+20 GOTO 400
345 IF G=0 AND -1<=V AND V<=1 LET S(C)=S(C)+10 GOTO 400
350 IF G=1 AND -4<=V AND V<=-1 LET S(C)=S(C)+20 GOTO 400
355 IF G=1 AND -1<=V AND V<=-.5 LET S(C)=S(C)+10 GOTO 400
360 IF G=2 AND 1<=V AND V<=4 LET S(C)=S(C)+20 GOTO 400
365 IF G=2 AND .5<=V AND V<=1 LET S(C)=S(C)+10 GOTO 400
```

300-365

AGE - UP TO 20 POINTS

```
400 IF LEFT(I$(1,11),3)="TAL" AND LEFT(I$(C,11),3)="SHO" THEN 405
401 IF LEFT(I$(1,11),3)="SHO" AND LEFT(I$(C,11),3)="TAL" THEN 405
402 IF LEFT(I$(1,11),3)="SAM" AND LEFT(I$(C,11),3)="SAM" THEN 405
403 GOTO 500
```

/COMPILER/ (cont.)

400-440

HEIGHT - UP TO 20 POINTS

```
405 IF ICO(I$(1,11),"TALL",0) LET B=1
410 IF ICO(I$(1,11),"SHORT",0) LET B=2
420 V=VAL(I$(1,18))-VAL(I$(C,18))
430 IF B=1 AND V<=-2 LET S(C)=S(C)+20 GOTO 500
435 IF B=2 AND V>=2 LET S(C)=S(C)+20 GOTO 500
440 IF -2<=V AND V<=2 LET S(C)=S(C)+20
500 IF ABS(VAL(I$(1,10))-VAL(I$(C,13))) <=1 THEN 505 ELSE 600
505 IF ABS(VAL(I$(1,13))-VAL(I$(C,10))) <=1 THEN 510 ELSE 600
510 IF VAL(I$(1,10))=VAL(I$(C,13)) LET S(C)=S(C)+5
515 IF VAL(I$(1,13))=VAL(I$(C,10)) LET S(C)=S(C)+5
520 S(C)=S(C)+10
```

500-520

PERSONALITY MATCH - UP TO 20 POINTS

```
600 IF I$(1,15)=I$(C,15) LET S(C)=S(C)+15
```

600

KISS ON FIRST DATE? UP TO 15 POINTS

```
700 FOR I=21 TO 25
701 FOR O=21 TO 25
710 IF VAL(I$(1,O))=VAL(I$(C,I)) LET L=L+1
715 NEXT O
720 NEXT I
730 IF ICO(I$(1,14),"SIM",0) LET P1=L*3 GOTO 750
740 P1=(5-L)*3
750 IF ICO(I$(C,14),"SIM",0) LET P2=L*3 GOTO 770
760 P2=(5-L)*3
770 IF LEFT(I$(1,14),3)=LEFT(I$(C,14),3) LET S(C)=S(C)+P1+P2 GOTO 800
780 S(C)=S(C)+ABS(P1-P2)
800 IF LEFT(I$(1,16),3)=LEFT(I$(C,16),3) LET S(C)=S(C)+10
```

700-780

INTEREST MATCH - UP TO 30 POINTS

```
900 IF I$(1,20)=I$(C,8) LET S(C)=S(C)+10
910 IF I$(1,8)=I$(C,20) LET S(C)=S(C)+10
911 PR.
913 P1←P2←L←V←B←G←0
914 NEXT C
915 PR. PR. PR. PR.
916 PR. "NUMBER OF PEOPLE COMPARED=":C-1
917 PR. PR. "THE COMPUTER FEELS THAT THE FOLLOWING PEOPLE WOULD MAKE
A BIG HIT WITH YOU:"
918 FOR B=2 TO C
919 IF S(B)>=110 LET Z=Z+1 GOSUB 3000
920 NEXT B
```

900-910

HAIR COLOR MATCH - UP TO 20 POINTS

```
921 IF Z=0 PR. "NOBODY"
922 PR. PR. "THE COMPUTER FEELS THAT THE FOLLOWING PEOPLE WOULD MAKE
A FAIRLY BIG HIT WITH YOU:"
923 FOR B=2 TO C
924 IF 80<=S(B) AND S(B)<110 LET Q=Q+1 GOSUB 3000
925 NEXT B
926 IF Q=0 PR. "NOBODY"
927 PR. PR. PR.
2105 PR. PR. PR. "DON'T BE TOO SHOOK IF YOU DIDN'T GET MATCHED UP WITH"
2107 PR. "SOMEONE.  ANOTHER RUN WILL BE MADE THE END OF THE WEEK"
2108 PR. "AND MAYBE YOU WILL HAVE BETTER LUCK.  MEANWHILE,"
2109 PR. "YOU ARE ALREADY ON FILE.  GOOD LUCK!"
2110 PR. PR. PR. VAR=ZERO END
```

921-926

PRINT OUT CHOSEN PEOPLE (IF ANY)

/COMPILER/ (cont.)

```
3000 PR. PR. PR. "NAME:        ":I$(B,2):" ":I$(B,3):" ":I$(B,1)
3010 PR. "ADDRESS:          ":I$(B,4)
3020 PR. "                  ":I$(B,5)
3030 PR. "PHONE NUMBER:     ":I$(B,6)
3040 RETURN
```

3000-3040

ROUTINE TO PRINT CHOSEN NAMES

/DATE/

```
90 STRING A(I) FOR I=1 TO 20
94 DIM B(40)
95 PR. PR. "     DATING SERVICE INSTRUCTIONS."
96 PR. PR. "     1. ANSWER THE QUESTIONS IN THIS PROGRAM AS TRUTHFULLY
AS YOU CAN. THE INFORMATION YOU SUPPLY WILL BE STORED IN A CON-"
97 PR."FIDENTIAL FILE."
98 PR. "     2. WHEN YOU HAVE RECEIVED THE MESSAGE 'NAME ON FILE',
YOU CAN BE SURE THAT YOUR NAME AND INFORMATION HAVE BEEN SAVED.
THAT IS ALL YOU HAVE TO DO."
99 PR. "     3. COMPARISONS ARE RUN ONCE EACH WEEK ON FRIDAY
OR SATURDAY.  TO FIND OUT IF YOU WERE MATCHED UP WITH ANYONE, SEE THE
NOTICE IN THE COMPUTER ROOM WHICH WILL BE POSTED EVERY MONDAY."
100 PR. "***NOTE***  IF YOU HAVE RUN THIS PROGRAM BEFORE,
YOUR NAME IS ALREADY ON FILE AND YOU SHOULD NOT BE RUNNING
IT AGAIN!  IF THIS IS THE CASE, ESCAPE NOW!"
101 PR. PR. "     SUPPLY THE FOLLOWING INFORMATION:"
110 PR. "LAST NAME-": ACCEPT A(1)
120 PR. "FIRST NAME-": ACCEPT A(2)
130 PR. "MIDDLE INITIAL-": ACCEPT A(3)
140 PR. "ADDRESS-": ACCEPT A(4)
150 PR. "CITY-": ACCEPT Y$
151 PR. "STATE-": ACCEPT N$
152 PR. "ZIP-": ACCEPT Z$
153 LET A(5)= Y$+" "+N$+" "+Z$
160 PR. "PHONE NUMBER-": ACCEPT A(6)
170 PR. "SEX-": ACCEPT A(7)
171 IF ICO(A(7),"M",0) OR ICO(A(7),"F",0) THEN 180
172 PR. "VERY FUNNY!" GOTO 170
180 PR. "AGE-": ACCEPT B(21)
190 PR. "HIEGHT(INCHES)-": ACCEPT B(22)
200 PR. "WEIGHT-": ACCEPT B(23)
210 PR. "COLOR OF HAIR (BLONDE, GRAY, BROWN, BLACK,RED)-": ACCEPT A(8)
220 PR. "COLOR OF EYES-": ACCEPT A(9)
```

STATEMENTS 101-690

INPUT ALL INFORMATION AND ANSWERS TO QUESTIONS

```
230 PR. "RATE YOUR PERSONALITY ON A 1 THROUGH 5 BASIS. LET 1 BE VERY SHY
AND 5 BE QUITE OUTGOING.   TYPE IN THE NUMBER WHICH YOU DECIDE ON."
231 PR. "-": ACCEPT A(10)
240 IF ICO(A(7),"F",0) LET R$="BOY" GOTO 260
250 R$="GIRL"
260 PR. PR. "ANSWER THE FOLLOWING QUESTIONS:"
270 PR. PR.
289 PR. "WOULD YOU LIKE A TALLER OR SHORTER ":R$:", OR ONE ABOUT THE SAME
← E
HEIGHT?"
290 PR. "-": ACCEPT A(11)
300 PR. "WOULD YOU LIKE AN OLDER OR YOUNGER ":R$:", OR ONE ABOUT THE SAME
← E AGE?"
310 PR. "-":ACCEPT A(12)
320 PR. "RATE THE PERSONALITY OF THE ":R$:" YOU WOULD LIKE IN THE
SAME MANNER WHICH YOU DID WITH YOURSELF. TYPE IN THE NUMBER."
330 PR. "-": ACCEPT A(13)
340 PR. "WOULD YOU LIKE SOMEONE WITH INTERESTS SIMILAR OR DIFFERENT
TO YOUR OWN?"
350 PR. "-": ACCEPT A(14)
360 PR. "WHAT COLOR HAIR WOULD YOU LIKE ON YOUR ":R$:" (BLONDE, GRAY,
BROWN, BLACK,RED)?"
370 PR. "-": ACCEPT A(17)
380 PR. "WOULD YOU KISS A ":R$:" ON YOUR FIRST DATE?"
390 PR. "-": ACCEPT A(15)
400 PR. "DO YOU USUALLY GOT TO BED BEFORE, AFTER, OR AT 11 P.M.?"
410 PR. "-": ACCEPT A(16)
500 PR. "  THE COMPUTER WILL NOW PRINT A LIST OF DIFFERENT HOBBIES."
501 PR. "AND INTERESTS WHICH YOU MIGHT HAVE.  THERE WILL BE A NUMBER"
502 PR. "BESIDE EACH ONE.  AFTER THE LIST IS THROUGH BEING PRINTED,"
503 PR. "A DASH WILL BE PRINTED.  PICK OUT ONE OF THE THINGS IN THE"
504 PR. "LIST WHICH INTERESTS YOU, TYPE THE NUMBER WHICH IS BESIDE"
505 PR. "IT, AND HIT A RETURN.  ANOTHER DASH WILL BE PRINTED. YOU"
506 PR. "MAY DO THIS FIVE TIMES FOR FIVE DIFFERENT INTERESTS BUT, "
507 PR. "IF YOU WANT TO STOP AFTER JUST TWO OR THREE, JUST"
508 PR. "HIT A RETURN WITHOUT A NUMBER AFTER THE DASH."
509 PR. "HERE IS THE LIST. "
510 PR. PR.
520 PR. "1-BASEBALL 2- BASKETBALL 3-FOOTBALL OR SOCCER 4-GOLF"
521PR. "5-HOCKEY 6-TENNIS 7-SWIMMING 8-BYCYCLING 9-OUTDOORS (CAMP-"
522 PR. "ING, HIKING, ETC.)"
532 PR. "10-BIOLOGY 11-CHEMISTRY 12-MATHEMATICS 13-PHYSICS "
533 PR. "14-COMPUTERS 15-ELECTRONICS 16-MECHANICS"
540 PR. "20-CLASSICAL MUSIC 21-COUNTRY -WESTERN 22-HARD ROCK"
541 PR. "23-POPULAR"
545 PR. "30-ACTING 31-DANCING 32-READING 33-WRITING 34-PHOTOGRAPHY"
546 PR. "35-SEWING 36-BASKET WEAVING 37-EATING."
```

```
600 PR. "OK, INPUT THE NUMBERS NOW. "
605 C=26
610 PR. "-": ACCEPT W$
620 IF W$="" THEN 690
630 IF LENGTH(W$)>2 PR. "BAD NUM" GOTO 610
650 B(C)=VAL(W$)
660 IF C=30 THEN 690
670 C=C+1 GOTO 610
690 DIM I$(30,25)
700 IF ICO(A(7),"F",0) OR ICO(A(7),"G",0) THEN 720
710 OPEN '159WR /BOYS/' FOR INPUT ,3 GOTO 725
720 OPEN '159WR /GIRLS/' FOR INPUT,3
725 INPUT FROM 3, C
727 FOR U=1 TO C
728 INPUT FROM 3, I$(U,N) FOR N=1 TO 25
729 NEXT U
730 CLOSE 3
```

700-730

OPEN APPROPRIATE DATA FILE AND READ ALL NAMES

```
731 FOR U=1 TO C
732 IF LEFT(A(1),3)=LEFT(I$(U,1),3) THEN 733 ELSE 735
733 IF LEFT(A(2),2)=LEFT(I$(U,2),2) THEN 734 ELSE 735
734 PR. "NAME ALREADY ON FILE, ":C:" ENTRYS." GOTO 800
735 NEXT U
```

730-735

CHECK IF NAME IS ON FILE ALREADY

```
736 IF ICO(A(7),"F",0) OR ICO(A(7),"G",0) THEN 738
737 OPEN '159WR /BOYS/' FOR OUTPUT, 4GOTO 739
738 OPEN '159WR /GIRLS/' FOR OUTPUT, 4
739 PRINT ON 4, C+1
749 PR. ON 4, A(I) FOR I=1 TO 16
750 PR. ON4, B(I) FOR I=21 TO 23
760 PR. ON 4, A(17)
770 PR. ON 4, B(I) FOR I=26 TO 30
780 [PRINT ON 4, I$(U,N) FOR N=1 TO 25] FOR U=1 TO C
790 CLOSE 4
795 PR. "NAME ON FILE, ":C+1:" ENTRYS."
800 PR. PR. "   REMEMBER TO SEE THE NOTICE WHICH WILL BE POSTED NEXT
MONDAY IN THE COMPUTER ROOM. "
805 PR. "GOOD LUCK!" END
```

736-795

IF NAME NOT ON FILE, OPEN FILE FOR OUTPUT AND ADD NAME

SAMPLE RUN of /DATE/

DATING SERVICE INSTRUCTIONS.

1. ANSWER THE QUESTIONS IN THIS PROGRAM AS TRUTHFULLY AS YOU CAN. THE INFORMATION YOU SUPPLY WILL BE STORED IN A CONFIDENTIAL FILE.

2. WHEN YOU HAVE RECEIVED THE MESSAGE 'NAME ON FILE', YOU CAN BE SURE THAT YOUR NAME AND INFORMATION HAVE BEEN SAVED. THAT IS ALL YOU HAVE TO DO.

3. COMPARISONS ARE RUN ONCE EACH WEEK ON FRIDAY OR SATURDAY. TO FIND OUT IF YOU WERE MATCHED UP WITH ANYONE, SEE THE NOTICE IN THE COMPUTER ROOM WHICH WILL BE POSTED EVERY MONDAY.

NOTE IF YOU HAVE RUN THIS PROGRAM BEFORE, YOUR NAME IS ALREADY ON FILE AND YOU SHOULD NOT BE RUNNING IT AGAIN! IF THIS IS THE CASE, ESCAPE NOW!

SUPPLY THE FOLLOWING INFORMATION:
LAST NAME-BAY!!OY
FIRST NAME-AVERAGE
MIDDLE INITIAL-F.
ADDRESS-2020 ELM STREET
CITY-ANYWHERE
STATE-PA.
ZIP-15000
PHONE NUMBER-4210000
SEX-MALE
AGE-16
HEIGHT(INCHES)-63
WEIGHT-150
COLOR OF HAIR (BLONDE, GRAY, BROWN, BLACK,RED)-BROWN
COLOR OF EYES-BLUS

RATE YOUR PERSONALITY ON A 1 THROUGH 5 BASIS. LET 1 BE VERY SHY AND 5 BE QUITE OUTGOING. TYPE IN THE NUMBER WHICH YOU DECIDE ON.
-4

ANSWER THE FOLLOWING QUESTIONS:

WOULD YOU LIKE A TALLER OR SHORTER GIRL, OR ONE ABOUT THE SAME HEIGHT?
-SAME HEIGHT
WOULD YOU LIKE AN OLDER OR YOUNGER GIRL, OR ONE ABOUT THE SAME AGE?
-OLDER
RATE THE PERSONALITY OF THE GIRL
YOU WOULD LIKE IN THE
SAME MANNER WHICH YOU DID WITH YOURSELF. TYPE IN THE NUMBER.
-2
WOULD YOU LIKE SOMEONE WITH INTERESTS SIMILAR OR DIFFERENT
TO YOUR OWN?
-SIMILAR
WHAT COLOR HAIR WOULD YOU LIKE ON YOUR GIRL
(BLONDE, GRAY,
BROWN, BLACK,RED)?
-BLACK
WOULD YOU KISS A GIRL ON YOUR FIRST DATE?
-YES
DO YOU USUALLY GO TO BED BEFORE, AFTER, OR AT 11 P.M.?
-AT 11

THE COMPUTER WILL NOW PRINT A LIST OF DIFFERENT HOBBIES AND INTERESTS WHICH YOU MIGHT HAVE. THERE WILL BE A NUMBER BESIDE EACH ONE. AFTER THE LIST IS THROUGH BEING PRINTED, A DASH WILL BE PRINTED. PICK OUT ONE OF THE THINGS IN THE LIST WHICH INTERESTS YOU, TYPE THE NUMBER WHICH IS BESIDE IT, AND HIT A RETURN. ANOTHER DASH WILL BE PRINTED. YOU MAY DO THIS FIVE TIMES FOR FIVE DIFFERENT INTERESTS BUT, IF YOU WANT TO STOP AFTER JUST TWO OR THREE, JUST HIT A RETURN WITHOUT A NUMBER AFTER THE DASH.
HERE IS THE LIST.

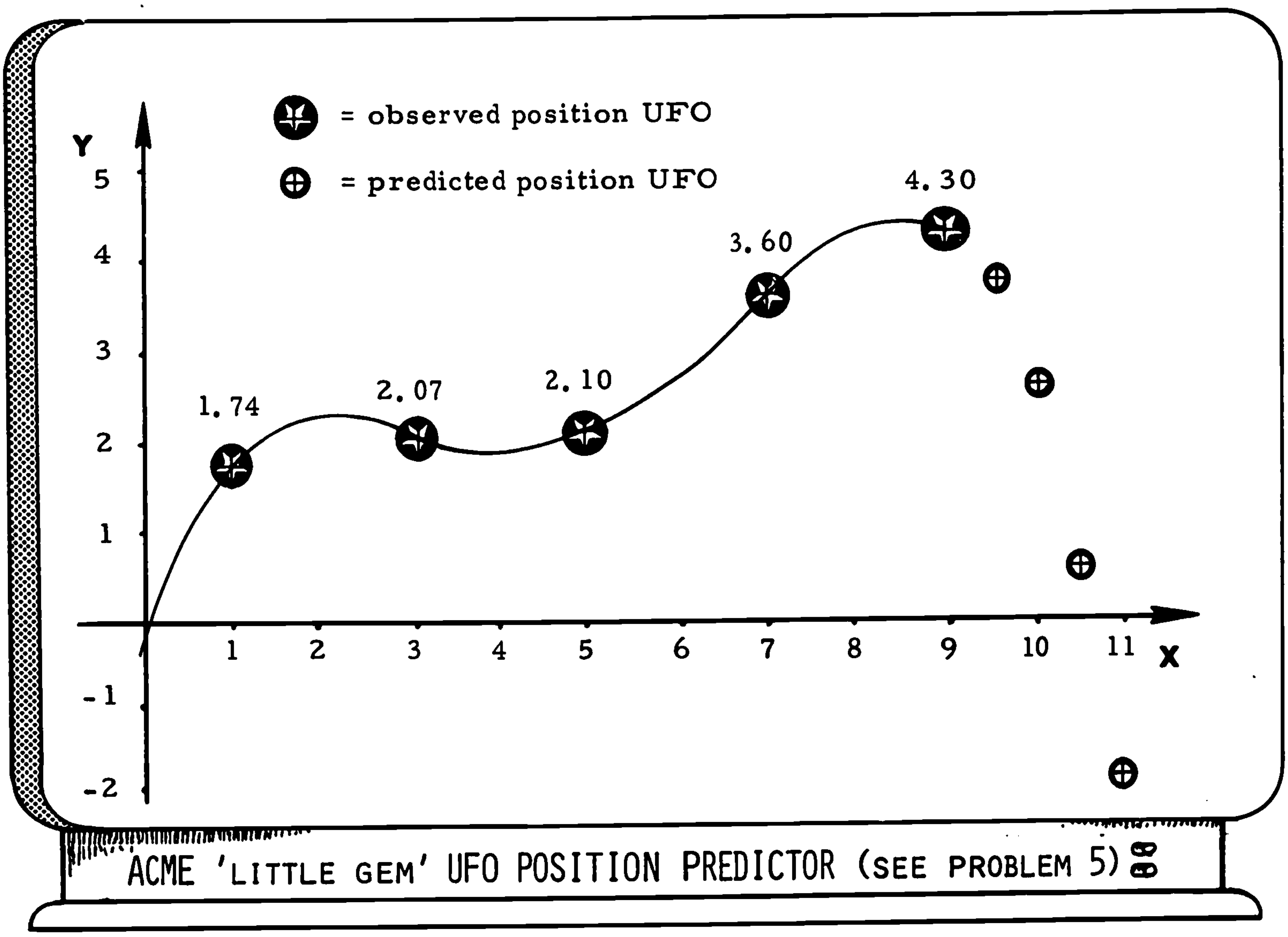
```
1-BASEBALL 2- BASKETBALL 3-FOOTBALL OR SOCCER 4-GOLF
5-HOCKEY 6-TENNIS 7-SWIMMING 8-BICYCLING 9-OUTDOORS (CAMP-
ING, HIKING, ETC.)
10-BIOLOGY 11-CHEMISTRY 12-MATHEMATICS 13-PHYSICS
14-COMPUTERS 15-ELECTRONICS 16-MECHANICS
20-CLASSICAL MUSIC 21-COUNTRY -WESTERN 22-HARD ROCK
23-POPULAR
30-ACTING 31-DANCING 32-READING 33-WRITING 34-PHOTOGRAPHY
35-SEWING 36-BASKET WEAVING 37-EATING.
OK, INPUT THE NUMBERS NOW.
-2
-6
-14
-22
-37
NAME ON FILE,  15 ENTRYS.


   REMEMBER TO SEE THE NOTICE WHICH WILL BE POSTED NEXT
MONDAY IN THE COMPUTER ROOM.
GOOD LUCK!
```

SAMPLE RUN of /COMPILER/

```
                 DATING COMPILER,    VERS. DEC. 1, 1971


 LAST NAME-      SMITH
FIRST NAME-      BETSY
       SEX-      FEMALE


NUMBER OF PEOPLE COMPARED= 10


THE COMPUTER FEELS THAT THE FOLLOWING PEOPLE WOULD MAKE
A BIG HIT WITH YOU:

NOBODY

THE COMPUTER FEELS THAT THE FOLLOWING PEOPLE WOULD MAKE
A FAIRLY BIG HIT WITH YOU:

NAME:             JIM H. JONES
ADDRESS:          139 HARTWOOD DR.
                  PITTSBURGH, PA. 15208
PHONE NUMBER:     731-8171

DON'T BE TOO SHOOK IF YOU DIDN'T GET MATCHED UP WITH
SOMEONE.  ANOTHER RUN WILL BE MADE THE END OF THE WEEK
AND MAYBE YOU WILL HAVE BETTER LUCK.  MEANWHILE,
YOU ARE ALREADY ON FILE.  GOOD LUCK!
```

LAGRANGIAN

Interpolation/Extrapolation



QUESTION: Can we use x-y data from a small number of observations to calculate x-y data for missing observations? This module studies the use of polynomials for solving this problem.

- On page 3 the simplest case (two observations) is considered, and you are shown how to write a linear interpolation/extrapolation program (these terms are explained on page 4).
- You will then be asked to write a quadratic interpolation/ extrapolation (page 5).
- An option will be suggested in which you write a version of this program which prints out the coefficients of the quadratic polynomial (page 6).
- Finally, you will write the n^{th} order polynomial interpolation/ extrapolation program. This most general version reads n data points and makes it possible to estimate values of the dependent variable with a polynomial of degree n-1 (page 7).

PROJECT SOLO / Dept. of Computer Science / Univ. of Pittsburgh (15213)
Module 0129 / Frank Wimberly (PS)

INTERPOLATION AND EXTRAPOLATION USING LAGRANGIAN POLYNOMIALS

Introduction

There are many real world mathematical problems in which you are given a table relating one variable to another. This table often comes from the experimental work of an engineer or scientist. The problem is that you may want to know the value of the dependent variable for some value of the independent variable which isn't included in the table. For example, Table 1 has acceleration figures for a Porsche 911S.

Table 1

V	T
0	0.0
10	-
20	2.7
30	-
40	5.1
50	-
60	-

The independent variable is V, the velocity which the Porsche reaches from a standing start (zero m.p.h.).

The dependent variable is T, the elapsed time required to reach V, starting at zero velocity.

Notice that elapsed time figures are missing for V = 10, V = 30, V = 50, and V = 60. (T is *actually* missing for *all* values of V *except* 0, 20, and 40. ... Think about it).

For purposes of comparison with other sports cars, it might be important, for example, to know the times for accelerating from zero to thirty and from zero to sixty. The solution to such modern problems is based on the work of an 18th century mathematician named Lagrange. The method used is called *"polynomial interpolation/extrapolation"* and it is based on the fact that given n points (x_1,y_1), (x_2,y_2), ... (x_n,y_n) in the xy plane there is one and only one polynomial of the form $y = a_1x^{n-1} + a_2x^{n-2} + \ldots + a_{n-1}x + a_n$ which passes through those points.

What this means is: given the n points (x_1,y_1), (x_2,y_2), ... (x_n,y_n) there is one and only one polynomial of degree $n-1$ such that

$$y_1 = a_1x_1^{n-1} + a_2x_1^{n-2} + \ldots + a_{n-1}x_1 + a_n$$
$$y_2 = a_1x_2^{n-1} + a_2x_2^{n-2} + \ldots + a_{n-1}x_2 + a_n$$
$$\vdots$$
$$y_n = a_1x_n^{n-1} + a_2x_n^{n-2} + \ldots + a_{n-1}x_n + a_n$$

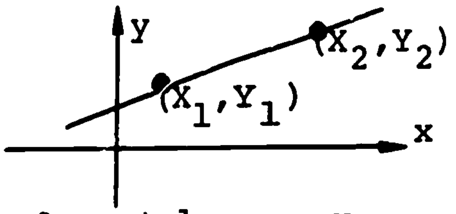
The proof of this fact is too involved to present in this module. If you are interested, you can find a proof in "Elementary Numerical Analysis" by S. D. Conte, McGraw-Hill 1965, page 73.

Using the Lagrangian Polynomial

In brief, what you do is to assume that the dependent variable y is related to the independent variable x by the polynomial of order n-1 (determined by the data that you have) for *all* values of x. You then find the polynomial (see pgs. 4, 6,8), and simply evaluate it for the missing values of x to complete the table. For example, the three points (0,0), (20,3.8) and (40,5.1) determine a second degree polynomial which can then be used to find the values of T corresponding to V = 30, and V = 60. What Lagrange did was to develop a method for finding the coefficients a_1, ..., a_n of the needed polynomial, given the points (x_1,y_1), ..., (x_n,y_n).

1. The Simplest Case: Linear Interpolation and Extrapolation

Consider two points in the x-y plane as in Figure 1.



In the equation:

$$1)\quad y = \frac{x - x_1}{x_2 - x_1}\, y_2 + \frac{x - x_2}{x_1 - x_2}\, y_1$$

if we substitute x_1 for x we get $y = 0 \cdot y_2 + 1 \cdot y_1 = y_1$.

On the other hand, setting x equal to x_2 gives us

$$y = 1 \cdot y_2 + 0 \cdot y_1 = y_2.$$

But if we take the original equation 1) and combine terms as follows:

$$2)\quad y = \frac{y_2 - y_1}{x_2 - x_1}\, x + \frac{x_2\, y_1 - x_1\, y_2}{x_2 - x_1}$$

We see that the equation has a graph which is a straight line since it is of the form $y = a_1 x + a_2$. (Be sure that you see how equation 2) follows from equation 1). What happens is that all terms which are multiplied by x are collected and the same is done for the terms which are not multiplied by x.)

Hence, we have the following facts:

1. Equation 2 has a graph which is a straight line.
2. The points (x_1,y_1) and (x_2,y_2) are on that line.
3. There is one and only one line through a pair of points.

Putting these together we get that 2) is the equation of <u>the</u> line through the points $(x_1 y_1)$ and (x_2,y_2).

Projects

1A. Study the listing of the interpolation program interaction below and write a program like the one that produced the listing.

```
>RUN
INPUT X. AND Y FOR THE FIRST POINT
?5, 60
INPUT X AND Y FOR THE SECOND POINT
?10, 120
INPUT A VALUE OF X FOR WHICH YOU WANT
Y TO BE ESTIMATED
?15
THE EXTRAPOLATED VALUE OF Y IS 180
FOR X = 15
```

NOTE: When an estimate of y is made for a value of x which is between given values of x the process is called interpolation; if the value of x is greater than (or less than) all of the given values of x the process is called extrapolation.

Your program should be able to decide whether it has been given an interpolation or extrapolation problem, and write the appropriate message.

1B. Use your program to find the missing data in the tables below.

TIME	TEMPERATURE
7 A.M.	43
10 A.M.	-
11 A.M.	67

YEAR	WORLD POPULATION
100 A.D.	137 million
1000 A.D.	275 million
2000 A.D.	-

You may not believe the result that you got for the population of the world in 2000 A.D. (the population of China in 1971 is about 800,000,000) even though the figures for 100 A.D. and 1000 A.D. are correct. This demonstrates the fact that polynomial interpolation/extrapolation involves an *assumption that may not be true*-namely that the polynomial describes the function for data other than the given data. Apparently world population is not a linear function of time.*

2. QUADRATIC INTERPOLATION AND EXTRAPOLATION

In the same way that two points determine a line (that is, a polynomial of the form $y = a_1x + a_2$) three points determine a quadratic polynomial of the form $y = a_1x^2 + a_2x + a_3$.

Equation 3) is the interpolation formula for the quadratic which is determined when three points (x_1, y_1) (x_2, y_2), (x_3, y_3) are given.

$$3)\quad y = \frac{(x-x_2)(x-x_3)}{(x_1-x_2)(x_1-x_3)}y_1 + \frac{(x-x_1)(x-x_3)}{(x_2-x_1)(x_2-x_3)}y_2 + \frac{(x-x_1)(x-x_2)}{(x_3-x_1)(x_3-x_2)}y_3$$

Substitute x_1, x_2, and x_3 for x in equation 3 and then simplify to verify that the three given points lie on the curve defined by the equation. Then by multiplication and combining terms convert equation 3) into the form $y = a_1x^2 + a_2x + a_3$.

You should get expressions for a_1, a_2, and a_3 that involve only the six numbers x_1, x_2, x_3, y_1, y_2, and y_3.

* Extrapolation is more likely to give false values than interpolation.

MORE PROJECTS

2A. Write an interpolation/extrapolation program in BASIC which reads in three (3) data points (x_1,y_1), (x_2,y_2), (x_3,y_3) and uses a quadratic polynomial (degree 2) to estimate values of the dependent variable y for other values of the independent variable x.

2B. Use this program and the data on page 1 to find the "zero to thirty" and "zero to sixty" times for a Porsche 911S.

3. PRINTING OUT THE QUADRATIC POLYNOMIAL (OPTIONAL)

Write a BASIC program that reads in three (3) points and prints our the *coefficients* of the quadratic polynomial determined by them. See the sample output below:

```
>RUN
WHAT ARE THE X AND Y COORDINATES OF THE FIRST POINT?
?0,2
WHAT ARE THE COORDINATES OF THE SECOND POINT?
?1,1
AND THE THIRD POINT?
?2,2
THE QUADRATIC IS
1*X↑2+-2*X+2
```

4. Nth Order Polynomial Interpolation and Extrapolation

It looks like the same reasoning that works for equations 1) and 3) might also work for n points. That is, it may be that equation 4) is the expression for the one and only polynomial of degree n-1 that fits the n points $(x_1,y_1)\ldots(x_n,y_n)$.

$$4)\quad y = \frac{\overbrace{(x-x_2)\ (x-x_3)\ldots(x-x_n)}^{\text{n-1 term product}}}{(x_1-x_2)\ (x_1,-x_3)\ldots(x_1-x_n)}\, y_1$$

$$+\ \frac{(x-x_1)\ (x-x_3)\ldots(x-x_n)}{(x_2-x_1)\ (x_2-x_3)\ldots(x_2-x_n)}\, y_2$$

$$+\ \ldots$$

$$+\ \frac{(x-x_1)\ (x-x_2)\ldots(x-x_{n-1})}{(x_n-x_1)\ (x_n-x_2)\ldots(x_n-x_{n-1})}\, y_n$$

Let's look more closely at one of these terms:

$$\frac{(x-x_1)\ (x-x_2)\ldots(x-x_{i-1})\ (x-x_{i+1})\ldots(x-x_n)}{(x_i-x_1)\ (x_i-x_2)\ldots(x_i-x_{i-1})\ (x_i-x_{i+1})\ldots(x_i-x_n)}\, y_i$$

Notice that $(x-x_i)$ is missing from the product in the numerator and (x_i-x_i) is missing from the product in the denominator.

This term is equal to $0 \cdot y_i$ for and $x = x_i, \ldots x_{i-1}, x_{i+1}, \ldots x_n$ (that is, any of the given x's other than x_i) and is $1 \cdot y_i$ for $x = x_i$.

In each numerator there is an n-1 term product each term of which is of the form $(x-x_i)$. If such a product is expanded it turns out to be a polynomial in x of degree n-1. Now each term in the sum (each term of equation 4) is therefore a polynomial of degree n-1. Furthermore,

$$\frac{y_i}{(x_i-x_1)\ (x_i-x_2)\ldots(x_i-x_{i-2})\,(x_i-x_{i+1})\ldots(x_i-x_n)}$$ is a constant,

and a constant times a polynomial is a polynomial of the same degree. Finally the entire right hand side of 4) is the sum of n polynomials of degree n-1. But the sum of polynomials of degree n-1 is also a polynomial of degree n-1.

Hence, just as for the line and the quadratic we have.

1) Equation 4) is a polynomial of degree n-1
2) The points $(x_i, y_i) \ldots (x_n, y_n)$ all "satisfy" equation 4.
3) There is one and only one polynomial of degree n-1 that is satisfied by n points.

Hence 4) is <u>the</u> polynomial of degree n-1 that fits the points.

EVEN MORE PROJECTS

4A. Write a program in BASIC which reads a number n, then reads n data points (xy pairs) and uses a polynomial of degree n-1 to extrapolate or interpolate.

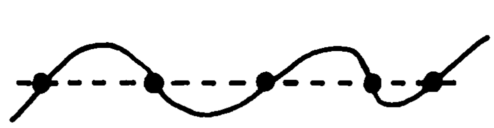
4B. Try your program on the following population data to see whether you get better results than you did in 1B.

YEAR	POPULATION OF THE WORLD
2000 B.C.	108 million
1000 B.C.	120 million
100 A.D.	137 million
1000 A.D.	275 million
1960 A.D.	3,003 million
2000 A.D.	?

5A. See cover picture for this problem. A UFO has been sighted in the range $0<x<9$. The cover picture shows five "sightings" at points marked ✪. Assume this curve is the path through space of an alien UFO. Have the computer output "prediction" points (⊕) which indicate where the saucer can be <u>intercepted</u> for X = 9, 9.5, 10, 10.5, 11, 11.5, and 12.

5B. Draw your own "smooth" UFO curve, and experiment to see if increasing the number of "sighting" points on the left side of the screen helps you better predict the path of the UFO on the right side of the screen. (You'll have to draw the <u>entire</u> path, and then <u>pretend</u> you only have data for the left half.)

<u>HINT</u>:



This curve is best fitted with a 5th degree polynomial since it "cuts" a straight line five times. Therefore six "sighting" points are needed.

The following is a solution program and run for the problem 2A.

```
JAN 11 12:24   /LAG1/

5 PRINT "WHAT ARE THE X AND Y VALUES FOR THE FIRST POINT?"
6 INPUT X1,Y1
10 PRINT "X AND Y VALUES FOR THE SECOND POINT?"
11 INPUT X2,Y2
15 PRINT "FOR THE THIRD POINT?"
16 INPUT X3,Y3
19 PRINT "INPUT A VALUE OF X FOR WHICH YOU WANT Y TO BE ESTIMATED"
20 INPUT X
30 P=Y1*((X-X2)*(X-X3))/((X1-X2)*(X1-X3))
40 P=P+Y2*((X-X1)*(X-X3))/((X2-X1)*(X2-X3))
50 P=P+Y3*((X-X1)*(X-X2))/((X3-X1)*(X3-X2))
60 PRINT "FOR X=";X;"Y=";P
70 END

>RUN

WHAT ARE THE X AND Y VALUES FOR THE FIRST POINT?
?20,50
X AND Y VALUES FOR THE SECOND POINT?
?30,40
FOR THE THIRD POINT?
?40,60
INPUT A VALUE OF X FOR WHICH YOU WANT Y TO BE ESTIMATED
?45
FOR X=    45   Y=     81.25
```

The following is a solution program and run for the problem 3A.

```
JAN 11 12:27   /LAG2/

10 PRINT "WHAT ARE THE X AND Y COORDINATES OF THE FIRST POINT?"
11 INPUT X1,Y1
20 PRINT "WHAT ARE THE COORDINATES OF THE SECOND POINT?"
21 INPUT X2,Y2
30 PRINT "AND THE THIRD POINT?"
31 INPUT X3,Y3
40 LET A=Y1/((X1-X2)*(X1-X3))
50 LET A=A+Y2/((X2-X1)*(X2-X3))
60 LET A=A+Y3/((X3-X1)*(X3-X2))
70 LET B=-(Y1*(X2+X3)/((X1-X2)*(X1-X3)))
80 LET B=B-(Y2*(X1+X3)/((X2-X1)*(X2-X3)))
90 LET B=B-(Y3*(X1+X2)/((X3-X1)*(X3-X2)))
100 LET C=X3*X2*Y1/((X1-X2)*(X1-X3))
110 LET C=C+X1*X3*Y2/((X2-X1)*(X2-X3))
120 LET C=C+X1*X2*Y3/((X3-X1)*(X3-X2))
130 PRINT "THE QUADRATIC IS"
140 PRINT A;"*X↑2+";B;"*X+";C
150 END
```

```
>RUN

WHAT ARE THE X AND Y COORDINATES OF THE FIRST POINT?
?0,2
WHAT ARE THE COORDINATES OF THE SECOND POINT?
?1,0
AND THE THIRD POINT?
?2,2
THE QUADRATIC IS
 2*X↑2+-4*X+ 2
```

The following is a solution program and run for the problem 4A.

```
JAN 11 12:29   /LAG3/

10 DIM X(20),Y(20),B(20)
20 PRINT "HOW MANY DATA POINTS (COORDINATE PAIRS) DO YOU HAVE?"
21 INPUT N
25 PRINT "FOR WHAT VALUE OF X DO YOU WANT Y TO BE ESTIMATED?"
26 INPUT X1
28 PRINT "NOW INPUT";N;"X Y PAIRS (DATA POINTS)"
30 FOR I=1 TO N
40 INPUT X(I),Y(I)
50 NEXT I
60 P=0
70 FOR K=1 TO N
80 B(K)=1
90 FOR J=1 TO N
100 IF J=K THEN 120
110 B(K)=B(K)*((X1-X(J))/(X(K)-X(J)))
120 NEXT J
130 P=P+B(K)*Y(K)
140 NEXT K
150 PRINT "FOR X=";X1;"Y=";P
160 END

>RUN

HOW MANY DATA POINTS (COORDINATE PAIRS) DO YOU HAVE?
?6
FOR WHAT VALUE OF X DO YOU WANT Y TO BE ESTIMATED?
?60
NOW INPUT     6    X Y PAIRS (DATA POINTS)
?0,0
?30,4.3
?40,5.7
?70,31
?80,42
?90,55
FOR X=    60    Y=     20.54547619
```

OPTICS

PROJECT SOLO
Department of Computer Science
University of Pittsburgh (15213)
Module #0067
J. M. Shore (T)
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This module will concern itself with reflection, refraction, and the physics of curved mirrors and lenses. There are three parts to the module. The first two parts require that you solve problems generated by programs already stored in the computer. The third part requires that you write your own program.

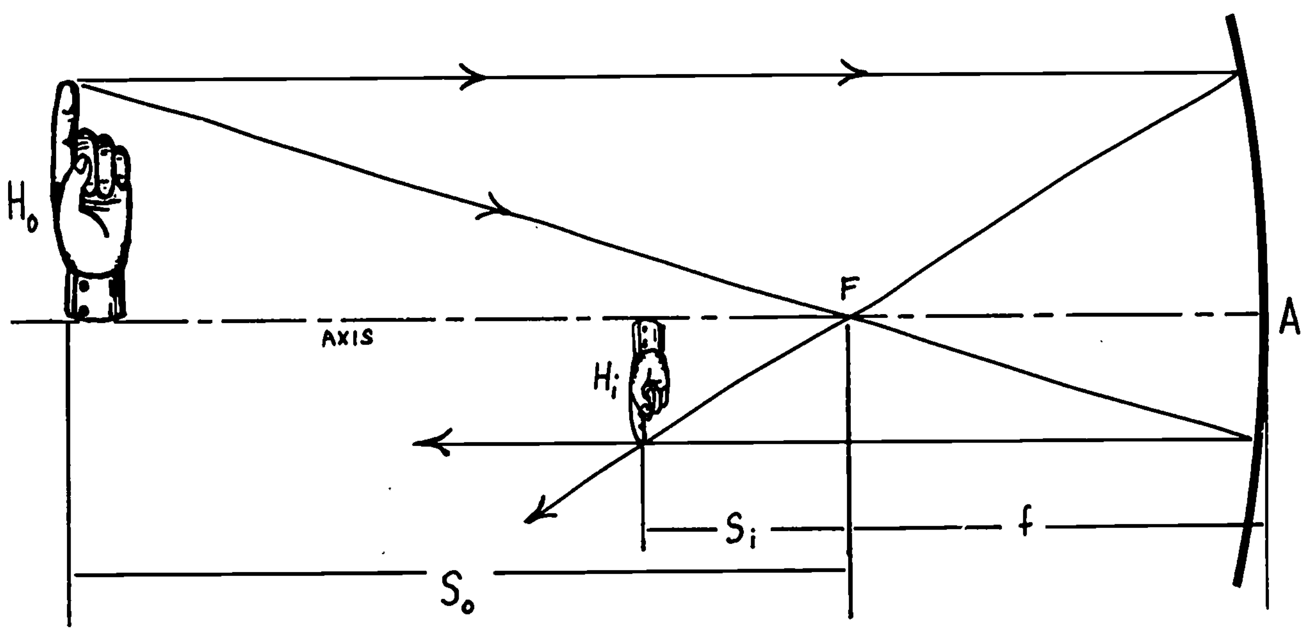


Figure 1. Location of an Image by Ray Tracing

PART 1 - REFLECTION

First we shall examine the formation of images by curved mirrors. The laws of reflection state: (1) the incident ray, the reflected ray, and the normal to the reflecting surface lie in the same plane; and (2) the angle of incidence is equal to the angle of reflection. You are no doubt familiar with the images formed by plane mirrors, such as the one on your medicine cabinet at home. The image of an object in a plane mirror is a virtual image. It is the same size as the object, erect, reversed right and left, and as far behind the mirror as the object is in front of the mirror.

The case is slightly different when we consider curved mirrors. Concave mirrors cause light to converge. Different types and sizes of images may be formed by concave mirrors depending upon the distance of the object from the mirror. Concave mirrors vary in size from an ordinary small mirror to the huge 200-inch reflector on Palomar Mountain, in California.

We can find the size and location of an image due to an object placed at a finite distance from a concave mirror by ray tracing as shown in Figure 1. All parallel rays as shown are brought to a common focus at F. This point F is called the focal point of the mirror and the distance FA is called the focal length of the mirror. We measure the distances S_o and S_i from the focal point to the object and image respectively. If we call H_o and H_i the height of the object and the image, it can be shown by similar triangles that:

$$H_i/H_o=f/S_o=S_i/f$$

using simple algebra it can be shown that:

$$S_iS_o=f^2$$

The difference between a real image and a virtual image is that there may be no light passing through a virtual image, but the light is sure to pass through a real image, and a photograph can be made by placing the film at the image. Whenever the object is placed closer to the mirror than its focal length, the image formed is virtual. Whenever the object is placed beyond the focal length of the mirror, the image formed is real. But whenever the object is placed at exactly the focal length from the mirror, no image is formed.

It's Problem Solving Time

After studying the sample run on page 5, logon the computer, enter NBS, and then type:

RUN 159AJS /MIRROR/

When you finish your computer run, go to part 2 of this module. Be sure to save your output from part 1.

PART 2 - INDEX OF REFRACTION

The index of refraction of a material, for which we use the symbol n, is defined as the ratio of the speed of light in a vacuum to the speed of light in the substance under consideration. Since the speed of light in air is only slightly different from the speed of light in a vacuum, for convenience we set the index of refraction of air equal to unity.

In 1621, Willebrord Snell discovered a relationship between the index of refraction of a material and the angles of incidence and refraction of light. This mathematical relationship, known as Snell's law, is:

$$n_1 \sin \theta_1=n_2 \sin \theta_2$$

where θ_1 and θ_2 are defined as in Figure 2. The index of refraction of a material may also be found in a table such as the one below.

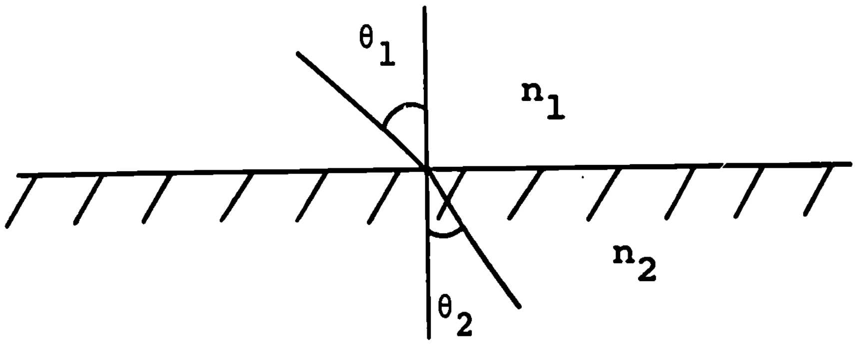


Figure 2

The Indices of Refraction of Some Common Materials

1.11	liquid hydrogen
1.22	liquid oxygen
1.33	water
1.38	liquid chlorine
1.47	glycerin
1.54	salt
1.60	quartz
1.66	liquid bromine
1.93	liquid sulfur
2.10	liquid tin
2.42	diamond
2.60	lead
3.34	iodine
4.22	sodium

LENSES

Lenses are instruments which use the laws of refraction to form images of objects. We shall be concerned with converging lenses, that is, lenses which bring parallel light incident upon them to a commom focus (the rays of light converge at a point). As in the case of the curved mirrors we shall call this point the focal point, and the distance from the lens to this point the focal length of the lens.

If a lens is thin compared to its focal length, no matter which side of the lens the light enters, the focal length is always the same. This result is also predicted by an application of Snell's law from which it can be shown that:

$$1/f=(n-1)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)$$

where R_1 and R_2 are the radii of the opposing surfaces and n is the relative index of refraction for light passing from any medium into the lens. This equation is known as the "lensmaker's formula". We can show that interchanging R_1 and R_2, which is the same as turning the lens over, has no effect on the focal length of the lens.

It's Problem Solving Time

To access the next practice program first enter NBS, and then type:

RUN 159AJS /REFRACT/

Before using the computer study the sample RUN of /REFRACT/ shown on page 6. When you finish your computer run, go to Part 3 of this module, being sure to save your output from Part 2.

PART 3 - YOU'RE ON YOUR OWN

There is no "pre-written" program on file for Part 3. You should write your own program(s) for the computer (or use the desk-calculator direct mode) to complete the following table:

Image distance (cm.)	Object distance (cm.)	Focal length	H_i/H_o
82	9		
30	30		
82			2
86			43
	100	67.8	
	53	16.3	
		15.5	3.75
		39.3	43

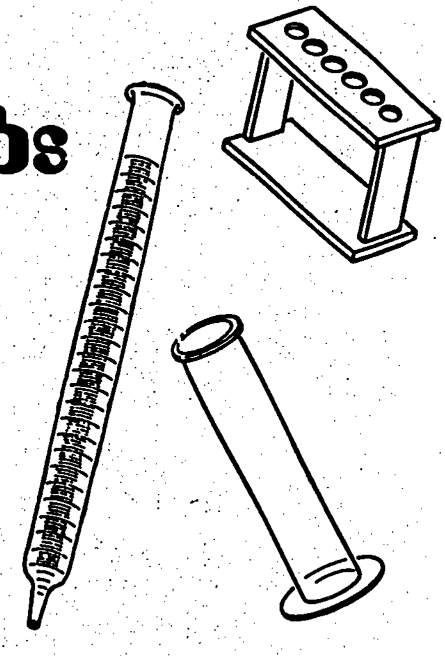
If you have any difficulties or questions concerning this module, please see your teacher. Also, if you have any suggestions for improving this module please let him (or her) know.

```
>RUN 159AJS /MIRROR/

THIS PRØGRAM WILL DEAL WITH THE PHYSICS ØF CURVED MIRRØRS.
THE FØRMULAS WHICH YØU WILL NEED MAY BE FØUND IN THE MØDULE.

PRØBLEM 1 ......

THE FØCAL LENGTH ØF A CURVED MIRRØR IS FØUND TØ BE 1.34E+1CM.
IF AN ØBJECT 3.72E+1CM. HIGH IS PLACED 7.71E+1CM. AWAY FRØM
THE MIRRØR.  FIND THE PØSITIØN AND THE HEIGHT ØF THE IMAGE
ØF THE ØBJECT.  FIRST TYPE IN THE IMAGE DISTANCE FRØM THE
MIRRØR IN CM.
?@NBS
VER. MAR 10  8:07
>PRINT 37.2*13.4/63.7

 7.825431711

>PRINT 7.825/37.4↑2*13.4
 2.818682796

>EXIT
?16.2
RIGHT
NØW TYPE IN THE HEIGHT ØF THE IMAGE IN CM.
?7.825
GØØD
WØULD YØU LIKE TØ TRY ANØTHER PRØBLEM LIKE THIS?
?NØ
Ø.K., HØW ABØUT TRYING A PRØBLEM LIKE THIS.

PRØBLEM 2 ......

THE IMAGE ØF AN ØBJECT PLACED 4.65E+1CM. AWAY FRØM A CURVED
MIRRØR IS FØUND TØ BE LØCATED 3.77E+1CM. AWAY FRØM THE MIRRØR.
CALCULATE THE FØCAL LENGTH ØF THE MIRRØR.
?@NBS
VER. MAR 10  8:07
>PRINT SQRT(46.5*37.7)

 41.86943993

>EXIT
?41.87
RIGHT
IS THE IMAGE REAL ØR VIRTUAL?
?REAL
THAT'S RIGHT
WØULD YØU LIKE TØ TRY ANØTHER PRØBLEM LIKE THIS?
?NØ
CHECK TØ MAKE SURE YØU UNDERSTAND THE RELATIØNSHIPS INVØLVED.
SHØW THIS TØ YØUR TEACHER.  GØØD BYE.
```

```
>RUN 159AJS /REFRACT/

THIS PRØGRAM WILL DEAL WITH REFRACTIØN AND THE PHYSICS ØF
THIN LENSES.
THE FØRMULAS WHICH YØU WILL NEED MAY BE FØUND IN THE
MØDULE.
 CALCULATE THE INDEX ØF REFRACTIØN ØF A MATERIAL
IF LIGHT INCIDENT UPØN IT AT AN ANGLE ØF 2.41E+1  DEGREES
IS REFRACTED TØ AN ANGLE ØF 1.62E+1  DEGREES
TYPE IN THE INDEX ØF REFRACTIØN ØF THE MATERIAL.
?@NBS
VER. MAR 10  8:07
>PRINT SIN(24.1/57.4)/SIN(16.2/57.4)

 1.463684021

>EXIT
?1.46
Ø.K.

DØ YØU THINK THAT THIS MATERIAL MIGHT BE ØNE ØF THØSE LISTED
IN THE MØDULE ØR SØME ØTHER MATERIAL?  TYPE IN THE NAME ØF THE
MATERIAL ØR 'ØTHER'.
?LIQUID CHLØRINE
NØ, MY CALCULATIØNS INDICATE THAT THE MATERIAL CØULD BE GLYCERIN.
WØULD YØU LIKE TØ TRY ANØTHER PRØBLEM LIKE THIS?
?NØ

NØW WE WILL LØØK AT THIN LENSES.

USING THE 'LENSMAKER'S FØRMULA' CALCULATE THE FØCAL LENGTH ØF A
THIN LENS MADE FRØM GLASS (N=1.5) IF THE RADII ØF THE ØPPØSING
SURFACES ARE 20 AND 25CM.
TYPE IN THE FØCAL LENGTH ØF THE LENS IN CM.
?@NBS
VER. MAR 10  8:07
>PRINT 1000/45.0

 22.22222222

>EXIT
?22.22
THAT'S RIGHT
WØULD YØU LIKE TØ TRY ANØTHER PRØBLEM LIKE THIS?
?YES

USING THE 'LENSMAKER'S FØRMULA' CALCULATE THE FØCAL LENGTH ØF A
THIN LENS MADE FRØM GLASS (N=1.5) IF THE RADII ØF THE ØPPØSING
SURFACES ARE 30 AND 5CM.
TYPE IN THE FØCAL LENGTH ØF THE LENS IN CM.
?8.57
GØØD
WØULD YØU LIKE TØ TRY ANØTHER PRØBLEM LIKE THIS?
?NØ

Ø.K. NØW TRY YØUR HAND AT WRITING A PRØGRAM TØ SØLVE THE PRØBLEMS
IN THE MØDULE.
STUDY HARD FØR THAT TEST COMING UP.
ØH YES, ARNIE ALLDERDICE SAYS 'GØØD LUCK'.
SHØW THIS TØ YØUR TEACHER.  GØØD BYE.
```

```
-COPY /INDEX/ TO TPT
1.11
LIQUID HYDROGEN
1.22
LIQUID OXYGEN
1.33
WATER
1.38
LIQUID CHLORINE
1.47
GLYCERIN
1.54
SALT
1.60
QUARTZ
1.66
LIQUID BROMINE
1.93
LIQUID SULFUR
2.10
LIQUID TIN
2.42
DIAMOND
2.60
LEAD
3.34
IODINE
4.22
SODIUM
```

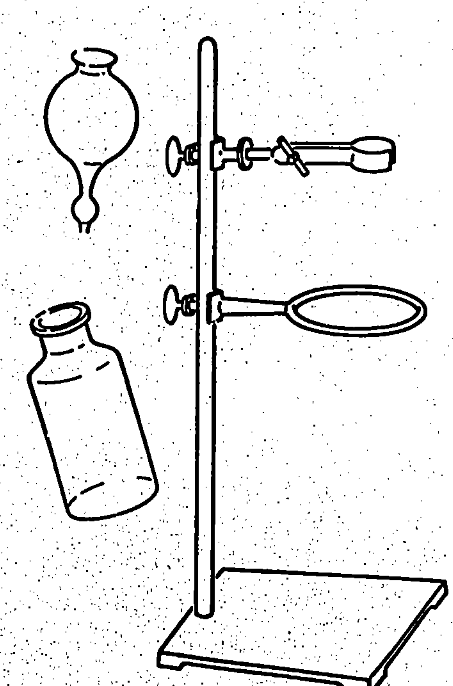
MODULES FOR
Computer Augmented Chemistry Labs



These modules are intended for use in connection with the experimental laboratory of an advanced placement chemistry course (12th Grade). They are designed to allow students to read in measurements, have the calculations done for them, and the results displayed in graphical fashion. It is intended that:

1. Students will be better able to concentrate on the experimental phase of their lab work.
2. They will be encouraged to carry out several runs of the experiment, since calculations can be done swiftly at another time.
3. When they write a similar program for another experiment in the book (or an improvement on this one), they will find it a valuable new way to organize their understanding of chemical theory.

Summary of Relevant Information:



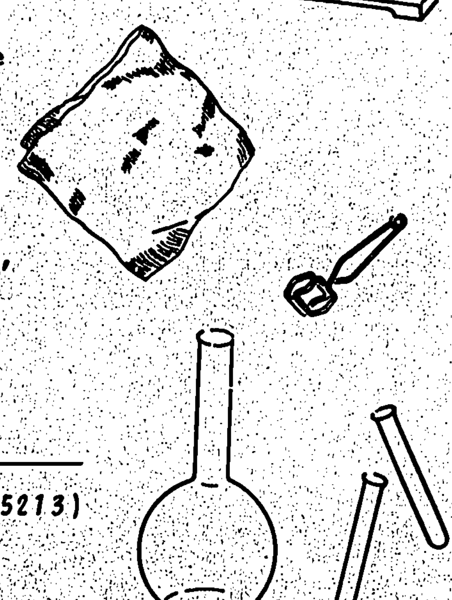
Module	Subject	Text Reference Lab. Manual*	Text**	Access Code
0124	Stoichiometry	Exp. 9	103-108	RUN 159DK /SPEX9/
0125	Gram-Equivalent, Mass of Magnesium	Exp. 13	121-123	RUN 159DK /SPEX13/
0126	Molecular Mass from Freezing Point Lowering	Exp. 16	207-221	RUN 159DK /SPEX16/

Suggested Use of the Modules:

(a) Students may use those programs already on file as "data-analysis" tools, and use the output as an integral part of their final lab report.

(b) Students may be invited (or assigned) to create similar programs for other experiments and/or improve the programs on file.

On the following pages you will find sample runs of each program. A flowchart of the program /SPEX16/ given and the listing which follows it shows the actual statements and programming details. The other programs are shorter than /SPEX16/ and can be programmed using the same techniques.



* Sienko, Michell J. and Robert A. Plane, Experimental Chemistry, 3rd Ed., (Laboratory Manual), McGraw-Hill, N.Y., 1966.

**Sienko, Michell J. and Robert A. Plane, Chemistry, 3rd Ed., McGraw-Hill, N.Y., 1966.

PROJECT SOLO / Dept. of Computer Science / Univ. of Pittsburgh (15213)
Modules #0124-6 / Dolores Kubiak (T) / Joel Berez (S)

SAMPLE RUNS -
/SPEX9/
/SPEX13/
CIRCLED NUMBERS ARE
TYPED IN BY STUDENT.

```
                 EXPERIMENT 9: STOICHIOMETRY

                          /DATA\

                 PART A: POTASSIUM CHLORATE

LIST THE FOLLOWING IN GRAMS.

MASS OF TEST TUBE PLUS MN-02: 21.88
MASS OF TEST TUBE, MN-02, AND POTASSIUM CHLORATE: 22.83
MASS OF TEST TUBE, MN-02, AND RESIDUE: 22.445

                 PART B: UNKNOWN MIXTURE

LIST THE FOLLOWING IN GRAMS.

MASS OF TEST TUBE PLUS MN-02: 7.94
MASS OF TEST TUBE, MN-02, AND UNKNOWN: 9.31
MASS OF TEST TUBE, MNO2, AND RESIDUE: 9.02

                          /RESU

                 PART A: POTASS

MASS (IN GRAMS) OF OXYGEN LOST

MASS (IN GRAMS) OF K-CL (RESIDU

NUMBER OF GRAM-ATOMS OF OXYGEN

NUMBER OF MOLES OF K-CL

NUMBER OF GRAM-ATOMS OF K IN OR

NUMBER OF GRAM-ATOMS OF CL IN O

NUMBER OF GRAM-ATOMS OF O IN OR

SIMPLEST FORMULA OF POTASSIUM C

                    PART B: UNKN

MASS (IN GRAMS) OF UNKNOWN MIXT

MASS (IN GRAMS) OF OXYGEN LOST

NUMBER OF GRAM-ATOMS OF OXYGEN

NUMBER OF MOLES OF K-CL-03 DECO

MASS (IN GRAMS) OF K-CL-03 IN O

PER CENT BY MASS OF K-CL-03 IN

DO YOU HAVE ANOTHER SET OF DATA

GOODBYE FOR NOW
```

```
     EXPERIMENT 13: GRAM-EQUIVALENT MASS OF MAGNESIUM

                          DATA
                       FIRST SAMPLE

TYPE THE MASS OF THE MAGNESIUM ( IN GRAMS ) : .0235
VOLUME OF HYDROGEN EVOLVED (IN MILLILITERS) 25.4
DIFFERENCE IN WATER LEVELS (IN MILLIMETERS) 535
TEMPERATURE OF WATER (IN DEGREES CENTIGRADE) 24.8
AMBIENT BAROMETRIC PRESSURE (IN MILLIMETERS) 731.7

                          DATA
                       SECOND SAMPLE

TYPE THE MASS OF THE MAGNESIUM ( IN GRAMS ) : .0207
VOLUME OF HYDROGEN EVOLVED (IN MILLILITERS) 24.0
DIFFERENCE IN WATER LEVELS (IN MILLIMETERS) 520
TEMPERATURE OF WATER (IN DEGREES CENTIGRADE): 23.5
AMBIENT BAROMETRIC PRESSURE (IN MILLIMETERS): 731.7

                         RESULTS
```

	FIRST SAMPLE	SECOND SAMPLE	UNITS
HG EQUIVALENT OF WATER COLUMN:	39.33823529	38.23529412	MM.
TOTAL PRESSURE IN GAS SAMPLE :	692.3617647	693.4647059	MM.
PARTIAL PRESSURE OF H2 :	669.1394436	671.9808335	MM.
VOLUME OF H2 AT STP :	20.5009841	19.53855694	ML.
MOLES OF H2 :	9.152225046E-04	8.722570063E-04	
MOLES OF H+ REDUCED :	1.830445009E-03	1.744514013E-03	
GRAM-EQUIVALENTS MG OXIDIZED :	1.830445009E-03	1.744514013E-03	
MASS OF 1 GRAM-EQUIVALENT MG :	12.83840808	11.86576883	GRAMS
AVERAGE	12.35208846		GRAMS/GRAM-EQUIVALENT

```
                        CONCLUSION

CONGRATULATIONS! ANOTHER SUCCESSFUL EXPERIMENT
```

*SAMPLE RUN OF /SPEX16/ CIRCLED NUMBERS ARE TYPED IN BY STUDENT.

PURE NAPHTHALENE

WHAT WAS THE MASS OF THE PAPER (IN GRAMS)? .985

MASS OF NAPHTHALENE PLUS PAPER (IN GRAMS)? 20.27

INCLUDING THE INITIAL READING,
HOW MANY TEMPERATURES DID YOU RECORD? 11

WHAT WAS THE INITIAL TEMPERATURE (IN °C)? 85

WHAT WAS THE 2ND TEMPERATURE? 81

WHAT WAS THE 3RD TEMPERATURE? 79.8

WHAT WAS THE 4TH TEMPERATURE? 79.6

WHAT WAS THE 5TH TEMPERATURE? 79.5

WHAT WAS THE 6TH TEMPERATURE? 79.5

WHAT WAS THE 7TH TEMPERATURE? 79.0

WHAT WAS THE 8TH TEMPERATURE? 78.[illegible]

WHAT WAS THE 9TH TEMPERATURE? 77.9

WHAT WAS THE 10TH TEMPERATURE? 76.7

WHAT WAS THE 11TH TEMPERATURE? 75.1

NAPHTHALENE AND SULPHUR

WHAT WAS THE MASS OF THE PAPER(IN GRAMS)? .985

MASS OF THE SULPHUR AND PAPER (IN GRAMS)? 3.045

INCLUDING THE INITIAL READING,
HOW MANY TEMPERATURES DID YOU RECORD? 9

WHAT WAS THE INITIAL TEMPERATURE (IN °C)? 85

WHAT WAS THE 2ND TEMPERATURE? 78.6

WHAT WAS THE 3RD TEMPERATURE? 77.4

WHAT WAS THE 4TH TEMPERATURE? 77.2

WHAT WAS THE 5TH TEMPERATURE? 76.9

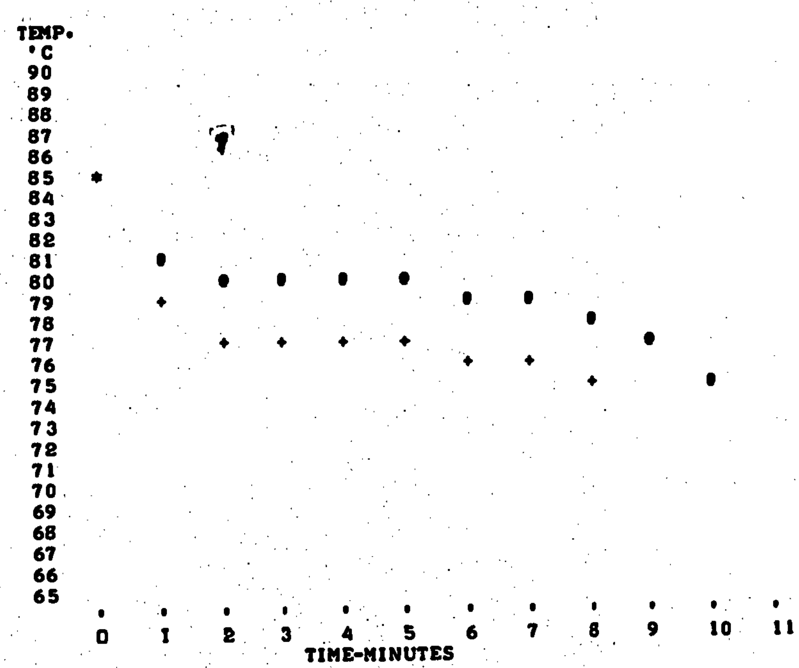
WHAT WAS THE 6TH TEMPERATURE? 76.6

WHAT WAS THE 7TH TEMPERATURE? 76.4

WHAT WAS THE 8TH TEMPERATURE? 76.1

WHAT WAS THE 9TH TEMPERATURE? 75.4

TIME-TEMPERATURE GRAPH OF COOLING NAPHTHALENE



THE PURE NAPHTHALENE IS REPRESENTED BY THIS SYMBOL: ●
THE SULPHUR SOLUTION IS REPRESENTED BY THIS SYMBOL: +
THE INTERSECTION IS THIS SYMBOL: *

FROM THE ABOVE GRAPH,

ESTIMATE THE FREEZING-POINT OF THE PURE NAPHTHALENE: 79.8

ESTIMATE THE FREEZING-POINT OF THE SULPHUR SOLUTION: 76.8

FREEZING-POINT OF PURE NAPHTHALENE	: 79.8	°C
FREEZING-POINT OF SOLUTION	: 76.8	°C
FREEZING-POINT LOWERING	: 3	°C
MOLES OF SULFUR PER 1000 GM. NAPHTHALENE	: 0.434782609	MOLES
MASS OF NAPHTHALENE IN SOLUTION	: 19.285	GRAMS
MASS OF SULPHUR IN SOLUTION	: 2.06	GRAMS
MASS OF SULPHUR PER 1000 GM. NAPHTHALENE	: 106.8187711	GRAMS
MASS OF SULPHUR IN ONE MOLE OF SULPHUR	: 245.6831734	GRAMS

FORMULA OF SULPHUR MOLECULE IN SOLUTION: S 8

/CONCLUSIONS\

1) THE ACTUAL VALUE FOR THE FREEZING-POINT OF NAPHTHALENE IS ABOUT 80°C.
YOU WERE CORRECT.

2) BASED ON THE MASSES OF SULPHUR AND NAPHTHALENE YOU USED, THE FREEZING-POINT OF THE SOLUTION SHOULD HAVE BEEN ABOUT
76.7 °C.
YOU WERE CORRECT.

3) THE FORMULA OF THE SULPHUR MOLECULE SHOULD BE S 8.
YOU WERE ABSOLUTELY RIGHT!

/FUN & GAMES\

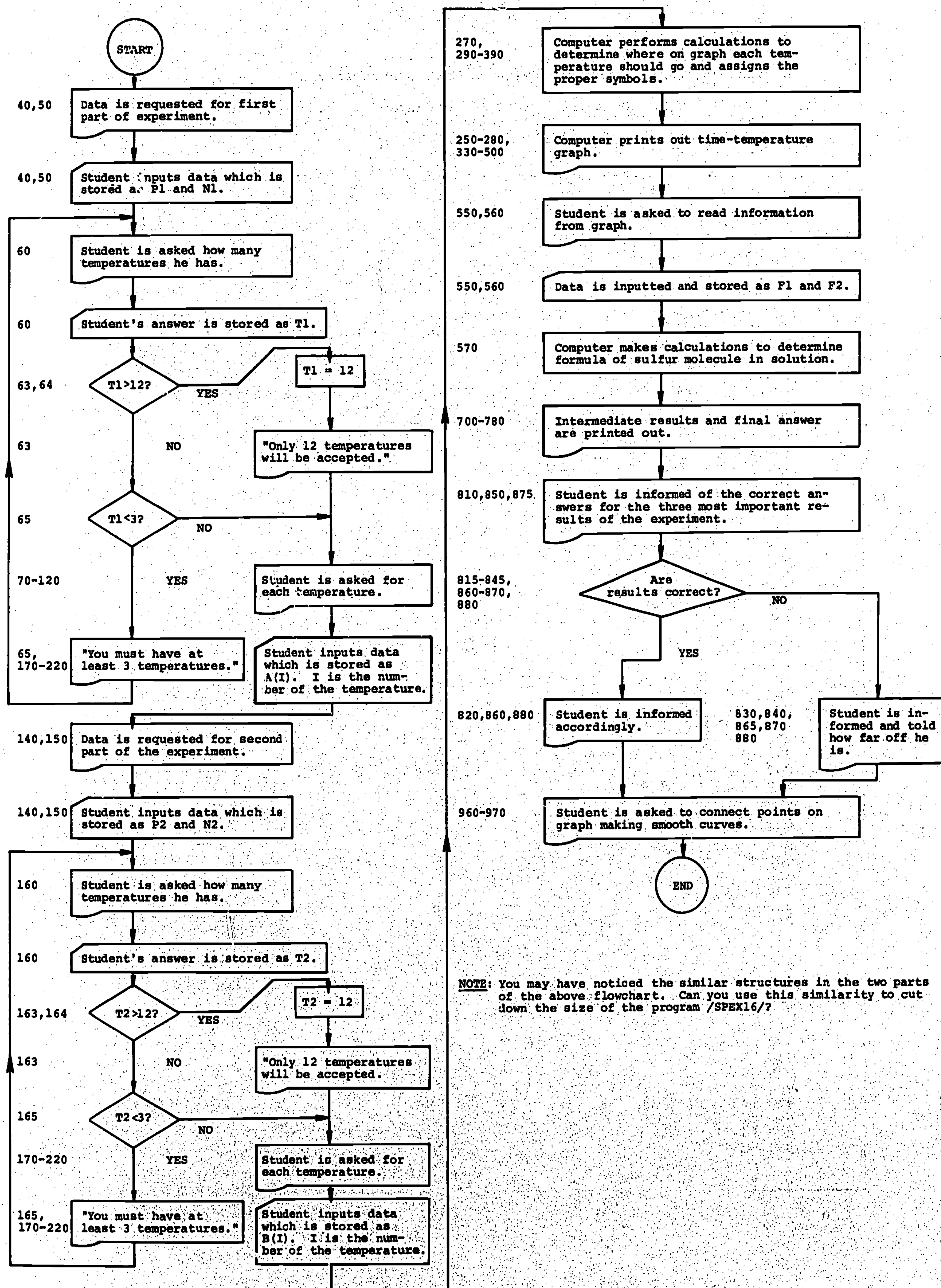
THERE IS A NUMBER ASSIGNED TO EACH POINT ON THE GRAPH. THESE ARE THE NUMBERS LABELED 'TIME-MINUTES'. FOR EACH OF THE TWO SETS OF POINTS AND WITHOUT LIFTING YOUR PENCIL, CONNECT THE DOTS IN NUMERICAL ORDER. TRY TO MAKE SMOOTH CURVES.

EXTRA CREDIT: COLOR THE TWO CURVES ON YOUR GRAPH WITH DIFFERENT CRAYONS OR PENS. (HINT: USE A BLEND OF THE COLORS ON THE PLACE WHERE THE CURVES OVERLAP.)

THIS HAS BEEN THE 16TH IN THE /SPEX/ LAB EXPERIMENTS SERIES.

COLLECT THE WHOLE SET!

FLOWCHART FOR /SPEX16/



NOTE: You may have noticed the similar structures in the two parts of the above flowchart. Can you use this similarity to cut down the size of the program /SPEX16/?

LISTING OF /SPEX16/

Notice that certain unusual features have been used by this student:

AC. P1 (line 40) means ACCEPT P1--produces an input request without a '?'.
EPS=.2 (line 815) sets the tolerance for the use of "equals approximately" =# in the following line.

```
5 DIM A(12),B(12),A$(12),B$(12)
10 PR.PR.PR.PR.
"EXPERIMENT 16: MOLECULAR MASS FROM FREEZING-POINT LOWERING"
20 PR.PR.PR.PR.PR.PR.TAB(26);"/DATA\"
30 PR.PR.PR.TAB(21);"PURE NAPHTHALENE"
40 PR.PR.PR."WHAT WAS THE MASS OF THE PAPER (IN GRAMS)? ";AC. P1
50 PR.PR."MASS OF NAPHTHALENE PLUS PAPER (IN GRAMS)? ";AC. N1
60 PR.PR."INCLUDING THE INITIAL READING,
HOW MANY TEMPERATURES DID YOU RECORD? ";AC. T1
63 IF T1>12 THEN PR.PR."ONLY 12 TEMPERATURES WILL BE ACCEPTED."
64 IF T1>12 THEN T1=12
65 IF T1<3 THEN PR.PR."YOU MUST HAVE AT LEAST 3 TEMPERATURES."
GOTO 60
70 PR.PR."WHAT WAS THE INITIAL TEMPERATURE (IN 'C)? ";AC. A(1)
80 PR.PR."WHAT WAS THE 2ND TEMPERATURE? ";AC. A(2)
90 PR.PR."WHAT WAS THE 3RD TEMPERATURE? ";AC. A(3)
95 IF T1=3 THEN 130
100 FOR I=4 TO T1
110 PR.PR."WHAT WAS THE";I;"TH TEMPERATURE? ";AC. A(I)
120 NEXT I
130 PR.PR.PR.TAB(18);"NAPHTHALENE AND SULPHUR"
140 PR.PR.PR."WHAT WAS THE MASS OF THE PAPER(IN GRAMS)? ";AC.P2
150 PR.PR."MASS OF THE SULPHUR AND PAPER (IN GRAMS)? ";AC.N2
160 PR.PR."INCLUDING THE INITIAL READING,
HOW MANY TEMPERATURES DID YOU RECORD? ";AC. T2
163 IF T2>12 THEN PR.PR.
"ONLY 12 TEMPERATURES WILL BE ACCEPTED."
164 IF T2>12 THEN T2=12
165 IF T2<3 THEN PR.PR."YOU MUST HAVE AT LEAST 3 TEMPERATURES."
GOTO 160
170 PR.PR."WHAT WAS THE INITIAL TEMPERATURE (IN 'C)? ";AC. B(1)
180 PR.PR."WHAT WAS THE 2ND TEMPERATURE? ";AC. B(2)
190 PR.PR."WHAT WAS THE 3RD TEMPERATURE? ";AC. B(3)
195 IF T2=3 THEN 230
200 FOR I=4 TO T2
210 PR.PR."WHAT WAS THE";I;"TH TEMPERATURE? ";AC. B(I)
220 NEXT I
230 PR.PR.PR.PR.PR.PR.TAB(25);"/RESULTS\"
240 PR.PR.PR.TAB(6);"TIME-TEMPERATURE GRAPH OF COOLING NAPHTHALENE"
250 PR.PR."TEMP."
260 PR." 'C"
270 FOR Y=90 TO 65 BY -1
280 PR. Y;
290 FOR I=1 TO 12
300 IF Y=INT(A(I)+.5) THEN A$(I)="@    " ELSE A$(I)="     "
310 IF Y=INT(B(I)+.5) THEN B$(I)="+    " ELSE B$(I)="     "
320 NEXT I
330 FOR I=1 TO 12
340 IF A$(I)=B$(I) THEN PR. A$(I): GOTO 380
350 IF A$(I)="     " THEN PR. B$(I): GOTO 380
360 IF B$(I)="     " THEN PR. A$(I): GOTO 380
370 PR."*    ";
380 NEXT I
385 PR.
390 NEXT Y
400 PR."   ";
410 FOR P=1 TO 12
420 PR."'    ";
430 NEXT P
440 PR.
450 PR."     ";
460 FOR P=0 TO 9
470 PR. P;"   ";
480 NEXT P
```

LISTING OF /SPEX16/ (CONTINUED)

```
490 PR." 10    11"
500 PR.TAB(23):"TIME-MINUTES"
510 PR.PR."THE PURE NAPHTHALENE IS REPRESENTED BY THIS SYMBOL: @"
520 PR."THE SULPHUR SOLUTION IS REPRESENTED BY THIS SYMBOL: +"
530 PR.TAB(1?):"THE INTERSECTION IS THIS SYMBOL: *"
540PR.PR.PR."FROM THE ABOVE GRAPH,"
550PR.PR."ESTIMATE THE FREEZING-POINT OF THE PURE NAPHTHALENE: ":AC.F1

560PR.PR."ESTIMATE THE FREEZING-POINT OF THE SULPHUR SOLUTION: ":AC.F2

570 L=F1-F2,E=L/6.9,S1=N1-P1,S2=N2-P2,M=1000*S2/S1,A=M/E,S=INT(A/32.0
64+.5)
700 PR.PR.PR.PR."FREEZING-POINT OF PURE NAPHTHALENE        :":F1:"  ","
 'C"
710 PR.PR."FREEZING-POINT OF SOLUTION                   :":F2:"  "," 'C"
715 PR.PR."FREEZING-POINT LOWERING                      :":L," 'C"
720 PR.PR."MOLES OF SULFUR PER 1000 GM. NAPHTHALENE     :":E:"  ","MOLES"
740 PR.PR."MASS OF NAPHTHALENE IN SOLUTION              :":S1,"GRAMS"
750 PR.PR."MASS OF SULPHUR IN SOLUTION                  :":S2,"GRAMS"
760 PR.PR."MASS OF SULPHUR PER 1000 GM. NAPHTHALENE     :":M,"GRAMS"
770 PR.PR."MASS OF SULPHUR IN ONE MOLE OF SULPHUR       :":A,"GRAMS"
780 PR.PR.PR."FORMULA OF SULPHUR MOLECULE IN SOLUTION:        S":S
800 PR.PR.PR.PR.PR.PR.TAB(23):"/CONCLUSIONS\"
810 PR.PR.PR.
"1) THE ACTUAL VALUE FOR THE FREEZING-POINT OF NAPHTHALENE
IS ABOUT 80'C."
815 EPS=.2
820 IF F1=#80 THEN PR."YOU WERE CORRECT." GOTO 845
830 IF F1#80 THEN PR."YOU WERE":ABS(F1-80):" DEGREE":
840IF ABS(F1-80)<=1 THEN PR." OFF." ELSE PR."S OFF."
845 J=(INT(10*(M/8*6.9/32.064+.5)))/10
850 PR.PR."2) BASED ON THE MASSES OF SULPHUR AND NAPHTHALENE
YOU USED, THE FREEZING-POINT OF THE SOLUTION SHOULD HAVE
BEEN ABOUT":80-J:" 'C."
860 IF F2=#80-J THEN PR."YOU WERE CORRECT." GOTO 875
865 IF F2#80-J THEN PR."YOU WERE":ABS(F2-80+J):"DEGREE":
870 IF ABS(80-J)<=1 THEN PR." OFF." ELSE PR. "S OFF."
875 PR.PR."3) THE FORMULA OF THE SULPHUR MOLECULE SHOULD BE S 8."
880 IF S=8 THEN PR."YOU WERE ABSOLUTELY RIGHT!" ELSE
PR."MAYBE YOU'LL HAVE BETTER LUCK ON THE NEXT EXPERIMENT..."
950 PR.PR.PR.PR.PR.PR.TAB(23):
952 GOSUB 992
953 PR."/FUN & GAMES\":
956 GOSUB 992
960 PR.PR.PR.PR."      THERE IS A NUMBER ASSIGNED TO EACH POINT ON THE
GRAPH. THESE ARE THE NUMBERS LABELED 'TIME-MINUTES'. FOR
EACH OF THE TWO SETS OF POINTS AND WITHOUT LIFTING YOUR
PENCIL, CONNECT THE DOTS IN NUMERICAL ORDER. TRY TO MAKE"
961 PR."SMOOTH CURVES."
970 PR.PR."EXTRA CREDIT: COLOR THE TWO CURVES ON YOUR GRAPH WITH
DIFFERENT CRAYONS OR PENS. (HINT: USE A BLEND OF THE COLORS
ON THE PLACE WHERE THE CURVES OVERLAP.)"
980 PR.PR.PR.PR."THIS HAS BEEN THE 16TH IN THE /SPEX/ LAB
EXPERIMENTS SERIES."
990 PR.PR."COLLECT THE WHOLE SET!"PR.PR.PR.PR.
991 END
992 G$=CHAR(007)
993 PR. G$: FOR J=1 TO 5
994 RETURN
```